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OH-58C HELICOPTER MAST MOUNTED SIGHT/DESIGNATOR SAFETY STATEMEN--ETC(U)
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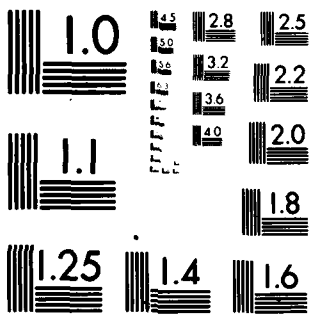

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Report No. C80-1337/034C

(1)

OH-58C HELICOPTER
MAST MOUNTED SIGHT/DESIGNATOR
SAFETY STATEMENT

(15)

CONTRACT DAAK10-77-C-0212

EXHIBIT E, SEQUENCE E002

DATE: 21 Feb[redacted]1980

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MMS/D FAILURE PROBABILITY

A brief failure analysis was conducted to assess the probability of a single failure occuring during laser operation which would cause the system to lose lock-on and slew the laser aimpoint. Pertinent failure elements are shown in Table 1. Detailed failure rates are shown for most items; however, several circuit card assemblies (CCA) do not have detailed breakdowns and a nominal value of 50 for failure rate/10^6 hours has been assessed for each CCA.

Based upon these individual elements and a total laser operating time of 45 sec (the maximum individual operating time recommended for the current tests), the reliability is 0.999973 or 27 failures per million hours. This assessment is considered to be conservative since worst case situations have been assumed.

TABLE 1. FAILURE RATES

ITEM	F.R. X 10^6
Platform	
Vidicon	150.00
Preamp	13.84
AZ and EL Motors	200.00
AZ and EL Resolvers	19.00
Accelerometers	190.00
Rate Gyros	190.00
Gyro Buffers	40.00
Camera/Tracker/Servo Electronics	
Sync Interface	70.3212
Reg. H.V. Power Supply	27.8448
Reg. L.V. Power Supply	20.8581
Reg. L.V. Power Supply	81.5971
Power Supply Assembly	50.8358
Camera Controls	72.8955
Power Supply	1.88
Platform Logic	46.2138
Vertical Tracker	97.25
Horizontal Tracker	133.6264
Interconnect Board	13.5239
Unreg. L.V.P.S.	27.2325
Video Amp	53.4433
MSL Axis Pulse Generator	74.3532
H&V Defl Amp	113.395
Video Processor	56.1629
Sync Gen CCA	50.
Variable Aimpoint Offset CCA	50.
Stab Comp AZ & EL CCA	50.
System Mode Logic CCA	50.
Gyro Precision Drive CCA	50.
Limit and Cage Logic CCA	50.
Power Supply CCA	50.
Gyro Excitation CCA	50.
Slave Cage Loop CCA	50.
Resolver/DC Conversion CCA	50.
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ABSTRACT

Avionics
Columbus OH

The Safety Statement was prepared by the Missile Systems Division of Rockwell International under Contract DAAK10-77-C-0212 for the design and fabrication of a mast mounted sight, with integrated laser designator, that is mounted above the rotor mast of an OH-58C helicopter. It was found, based upon design data, operating and maintenance procedures, and experience gained in the laboratory, that the GFP laser within the mast mounted sight can be used and maintained with hazards controlled within acceptable limits.

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TABLES & FIGURES

1.0 INTRODUCTION

1.1 Scope

This safety statement was prepared by the Missile Systems Division of Rockwell International under Contract DAAK10-77-C-0212 for the design and fabrication of a mast mounted sight, with integrated laser designator, that is mounted above the rotor mast of an OH-58C helicopter. This report addresses only the hazards and precautions directly resultant from the use of the GFP laser, as required by the contract. The safety statement has been prepared for submittal in accordance with CDRL Sequence No. E002 and Data Item Description DI-H-1322A.

1.2 Purpose

The safety statement has been prepared to provide ARRADCOM with a formal comprehensive safety report on the final design, operation and maintenance of the hardware directly associated with the GFP laser. It includes a summarization of tests, analyses, and other data collected during the design and development phases which identifies the hazards which may be presented by the hardware, together with the action taken, or the recommended procedures to be followed to minimize these hazards and to reduce the exposure of personnel, equipment, and property.

2.0 SYSTEM DESCRIPTION

The Mast Mounted Sight/Designator described in this report consists of the following hardware items:

	Part No.
Camera Tracker Electronics Assembly	MCL-121-2-103
Cabling Interface	MCL-121-2-104
Pilots Imaging Display and Controller	MCL-121-2-106
Video Tape Recorder	MCL-121-2-108
Instrumentation Tape Recorder	MCL-121-2-109
Instrumentation Power Supply	MCL-121-2-110
Instrumentation Breakout Box	MCL-121-2-111
Static Inverter	MCL-121-2-112
Time Code Generator	MCL-121-2-113-00
Character Generator	MCL-121-2-113-003
TV Monitor	MCL-121-2-114
Servo Electronics Assembly	MCL-121-2-581
Operators Imaging Display and Controller	MCL-121-2-601
Mast Mounted Sight Assembly	MCL-121-2-701
Laser Lock	MCL-121-2-115

These items are designed for installation on an OH-58-C helicopter to permit target acquisition, laser ranging and designation to be performed from a masked position, thereby significantly improving suvivability and combat effectiveness of ground and airborne units employing laser weapons. The items are integrated into the helicopter as shown in MSD drawing MCL-212-2-100, reference (1).

The hardware items directly associated with the operation of the laser are the Camera Tracker Electronics Assembly, Servo Electronics Assembly, Operator's Imaging Display and Controller, Mast Mounted Sight Assembly, Laser Lock, and parts of the Cabling Interface.

The part of the Camera Tracker Electronics Assembly related to use of the laser is the circuitry which generates video cues of laser operation.

The parts of the Servo Electronics Assembly related to use of the laser are: protective fusing; relay switching for powering the system, powering the laser, and arming the laser; the laser encoder module which provides signals for synchronizing the laser system and switches for setting pulse repetition frequency codes as defined in "Memorandum for the Assistant Secretaries of the Military Department (Research and Development) DAAJ02-75-C-005 - Secret"; an ON-OFF switch for disabling the rangefinder during laboratory operations; and a range receiver interface module which accepts signals from the range counter in the mast mounted sight assembly and processes them for use in the OIDC range display circuitry.

The parts of the Operator's Imaging Display and Controller related to use of the laser are an ON_OFF switch for system power, an ON-OFF switch for laser power, a 3 position switch for selecting laser code, a push-button switch for arming the laser, an indicator light to show the laser is armed, a trigger switch to fire the laser, an ON-OFF Switch for boresight enable, an indicator light to show laser output power low or shut-down for an overtemperature condition, a push-button switch to enable offset aimpoint, a force transducer thumb control for setting aimpoint offset, circuitry and 4-digit display for laser range, and a television monitor to show laser aimpoint and operating cues.

The parts of the Mast Mounted Sight Assembly related to use of the laser are a laser power supply, a laser transmitter, a GVS-5 range receiver, a range counter, and a -600 VDC power supply. The power supply module converts the 28 VDC input current to a 700 to 930 VDC level appropriate for flashlamp discharge. Pseudo-simmer, energy storage, and pulse shaping functions are accomplished by the power supply circuits. The power supply converter also provides a 300 VDC and a 250 VDC source for the Pockels cell trigger and the flashlamp trigger modules, respectively. The transmitter module contains a flashlamp, the input energy to which is converted to 1.064 μm, Q-switched laser output pulses. The Porro prisms, optical pumping cavity, vertical and horizontal transfer prisms, retardation plate, dielectric polarizer, Pockels cell electro-optic switch, folding mirror, and wideband output filter assemblies mounted to the optical bed are included in this module. Also included are a Pockels cell driver module and a flashlamp trigger module which provide a 7 KV pulse to ionize the flashlamp.

The range receiver module receives and detects reflected 1.064 μm energy and provides two pulses used in the derivation of target range. The range counter module converts the pulses from the receiver into a 11-bit serial data format at 5V. The range receiver receives all its power from a GVS-5 power supply, also located in the MMS/D above the rotor.

The laser system has an electrical input of 28 VDC primary helicopter power. All other required voltages are derived internally from the 28 VDC primary power.

3.0 CONCLUSIONS

Based upon the design data, operating and maintenance procedures, and experience gained in the laboratory, it is judged that operation and maintenance of the Mast Mounted Sight can be accomplished with hazards resultant to use of the GFP laser controlled within acceptable limits.

Potential hazards associated with the laser subsystem are laser radiation upon personnel, equipment, or property in the vicinity of the laser, and high voltages contacting operating and maintenance personnel.

Laser radiation hazards are controlled by design of the subsystem such that a normally functioning subsystem will radiate only after a number of conditions are met, by safety and operating procedures being required of operating personnel, by warning decals and labels being attached to the equipment, by using a maintenance manual which has adequate warnings when the equipment may be expected to radiate, and by design of the subsystem such that the number of failures within the subsystem which can cause premature or unanticipated radiation are minimized.

High voltage hazards are controlled by design of the subsystem such that the high voltages are confined to the parts of the subsystem located in an enclosure above the rotor plane of the helicopter, and by using a maintenance manual which has adequate precautions and warnings specifically stating those circumstances under which high voltages might be contacted by maintenance personnel.

4.0 SEQUENCE OF OPERATIONS

4.1 Ground Operating Procedure

Appendix A of this report gives the operating procedure developed at Rockwell International for the Mast Mounted Sight. It is recommended that this or a similar procedure be used in all operations. Safety features of this procedure are:

1. Proper equipment installation verification
2. Cable connections before power turn-on verification
3. Controls accessibility verification
4. Verification that all switches are OFF before starting preparations
5. Highlighted warning immediately prior to starting laser turn-ON Procedure.
6. Turn-OFF procedure.

4.2 Safety Operating Procedure

Appendix B of this report gives the safety procedures to be followed at Rockwell International when operating, aligning, testing, or repairing the Mast Mounted Sight or its laser subsystem. This document was developed to preclude hazards presented by laser radiation from causing damage to personnel, equipment, or property. It is recommended that a similar procedure be used for Army operation of the Mast Mounted Sight/ Designator.

4.3 Equipment Maintenance

An operation and maintenance manual for the laser subsystem, reference (2) was developed by International Laser Systems, Inc. This manual contains the following safety features:

1. Two pages immediately prior to the table of contents contain Considerations for safe operation and maintenance of the laser. They mention both radiation and high voltage hazards, and give references to related laser safety publications. These pages are highlighted by being printed on paper of a color contrasting to that of the remainder of the manual. This is in general accordance with paragraph 3.5.2 of MIL-M-38784A, reference (3).

2. Highlighted warnings, cautions, and notes in general accordance with paragraph 3.3.9 of MIL-M-38784A are placed throughout the test where applicable.

It is recommended that this manual be referred to for all maintenance actions required by the laser system.

5.0 DESIGN ANALYSIS

5.1 General Safety Considerations

Safety of personnel and equipment were considered paramount during design of the laser subsystem of the Mast Mounted Sight/Designator. The following considerations were incorporated into the design:

1. A safety electrical "jumper plug" is incorporated on the servo electronics interface chassis. When separated from the chassis, this plug removes primary 28 VDC electrical power from the laser subsystem. When operating in the laboratory, the "jumper plug" is replaced with a plug coupling the laser subsystem to the laboratory door interlock system, such that opening a laboratory door will remove 28 VDC power from the laser.

2. An indicator light on the OIDC shows when the laser is "armed" (ready to be fired).

3. A flashing cue on the television display shows when the laser is firing.

5.1 General Safety Considerations (Cont.)

4. A means of blocking the laser path when the environmental cover is removed has been provided.

5. A key switch on the PIDC must be ON for powering the laser. In addition, on the OIDC the system power and laser power switches must be ON. After these three switches are ON, the laser arm momentary pushbutton switch must be actuated, followed by actuation of the trigger switch to fire the laser.

6. Electrical cables interconnecting the laser related hardware must be properly connected before the laser can be armed and fired.

7. Warning labels of laser radiation danger are affexed to the sight on the environmental cover on both sides of the window. In addition, the following label is affized to the outside of the azimuth housing adjacent to the heat exchanger assembly.

> <u>CAUTION</u>
>
> This electronic product has been exempted from FDA radiation safety performance standards prescribed in the Code of Federal Regulations, Title 21, Chapter 1, Subchapter J, pursuant to Exemption No. 76 EL-01 DID issued on 26 July 1976. This product should not be used without adequate protective devices or procedures.

8. A test switch is provided in the servo electronics interface chassis to disable the range receiver during ground or laboratory operation of the laser.

9. All high voltages required for the laser subsystem only are generated within the Mast Mounted Sight assembly, located above the helicopter rotor plane, and are not found in the cockpit-mounted equipment.

5.2 Failure Mode Analysis

Potential hazards within the laser subsystem involve high voltage contact with personnel and laser beam contact with personnel or equipment.

All high voltages within the laser subsystem are nornally confined within the Mast Mounted Sight assembly. No normally expected failure modes of electronic parts will cause those voltages to be imposed upon wiring which interfaces this unit. However, it is possible for a wiring short caused by a loose part within the assembly to allow such a condition. The probability of this occurrence cannot be quantitatively analyzed, but is

5.2 Failure Mode Analysis(Cont.)

considered remote. Warning of potential hazards due to high voltage are contained in the maintenance manual and precautions which should be taken by maintenance personnel are given.

Laser radiation is initiated by actuating a key-operated switch, turning ON two toggle switches, depressing the laser arm button, and actuating the laser fire trigger switch. The operating procedure (Appendix A) calls for a specific sequence of actuating these switches, which normally precludes laser operation until the trigger switch is actuated. If this procedure is followed, single failure modes associated with the trigger switch or its circuitry only will cause unanticipated laser operation. Using MIL-HDBK-217B, the failure rate for this occurrence is about one failure per 2000,000 hours of operation in an airborne environment. Note that this is not the probability of a hazardous occurrence; use of the procedures of Appendices A and B should preclude any damages.

It is possible for failure to occur in one of the other switches or circuitry which could cause the laser to be armed when not desired; however, under these conditions, the Laser Armed indicator light will be illuminated and the operator must actuate the trigger switch in order for the laser to radiate. Because of the human elements involved (ignoring the armed light and actuating the trigger) the probability of this occurrence cannot be quantitatively determined, but is considered remote.

During operation of the system in the laboratory at Rockwell International, a failure occurred in the system such that after actuating the system power switch, key switch, and laser power switch, the laser became armed prior to depressing the laser arm button. This failure was indicated by the armed indicator being illuminated and was verified by firing the laser arm button. The failure was corrected by the manufacturer and the unit returned to Rockwell for continued operation. No other failures were noted during operation at Rockwell International which had a potential impact on safety.

6.0 REFERENCES

(1) Rockwell International Drawing MCL-121-2-100, OH-58C Mast Mounted Sight Installation.

(2) International Laser Systems, Inc., Document Number M-1362, "Operational and Maintenance Manual, Laser Rangefinder/Designator, ILS Model FWL-105".

(3) MIL-M-38784A, Military Specification, Manuals, Technical: General Style and Format Requirements.

APPENDIX A

MAST MOUNTED SIGHT/DESIGNATOR (MMS/D) DESCRIPTION AND OPERATIONAL PROCEDURE

ABSTRACT

This document, prepared by the Missile Systems Division of Rockwell International under Contract DAAK10-77-C-0212, provides a description of the system elements, operating procedures, and safety precautions for the Mast Mounted Sight/Designator (MMS/D) system as installed on the OH-58C helicopter. The MMS/D system provides a capability for helicopter operation in a masked position while acquiring, tracking and designating mobile targets and, thereby, significantly improving helicopter survival.

MAST MOUNTED SIGHT/DESIGNATOR (MMS/D) DESCRIPTION AND OPERATIONAL PROCEDURE

I. System Description

A. System Block Diagram

The Mast Mounted Sight/Designator (MMS/D) system consists of a three-gimbal, two-axis tracking and laser designating platform which mounts over-the-rotor, a pantograph-mounted control and display unit located on the floor in front of the left hand front seat, a servo electronics and interface chassis which mounts on the left side of the floor in the back seat, and a camera/tracker chassis which mounts on the left side of the rear seat. The initial system also includes as instrumentation: a TV monitor, video tape recorder and time code/video character generators mounted on the left side of the back seat, and a 14-channel analog-data-recording/reproduce system mounted in the baggage compartment. The baggage compartment also contains two instrumentation power supplies and an instrumentation breakout box. The instrumentation equipment includes a 3-axis translational accelerometer package and two orthogonal angular rate gyros mounted near the CG of the platform and an angular accelerometer (sensing axis along the line-of-sight) and two rate integrating gyros (sensing axes normal to the line-of-sight) mounted on the gimbaled payload.

The MMS/D system block diagram is shown in Figure 1. This diagram presents the major components in the system, the functions and location of each component, and the principal signal interfaces. Table 1 summarizes the principal design factors and the performance capability of this system.

B. Modes of Operation

The MMS/D has the following modes of operation: ACTIVATE, ELEC-CAGE, SLEW, BORESIGHT, AUTO-TRACK, LASE, and AIMPOINT OFFSET. Each of these modes is commanded from the controls on the hand grips and control panel. Table 2 presents a definition of each mode and lists the controls which command the mode. A general description of the modes is presented in the following paragraph:

<u>General Description of Mode Control</u> (Refer to Figure 2)

When system power (1) is turned on, there is a time delay of approximately 25 seconds before the control loops are activated. After this delay times out, the system switches to a position mode called forward cage as indicated by the electrical cage status light (VII). The operator may then select the gimbal position cage mode (20) to command platform AZ and EL positions relative to the aircraft using the position pots (9) on the control panel. The operator may assess the sight's relative angular position to the aircraft in a qualitative way by watching the gimbal angle cue (III) on his monitor. He may also get a more accurate quantitative assessment of position by examining the gimbal angle display digital readouts (III) on his control panel. The system is switched to the Slew mode by squeezing the

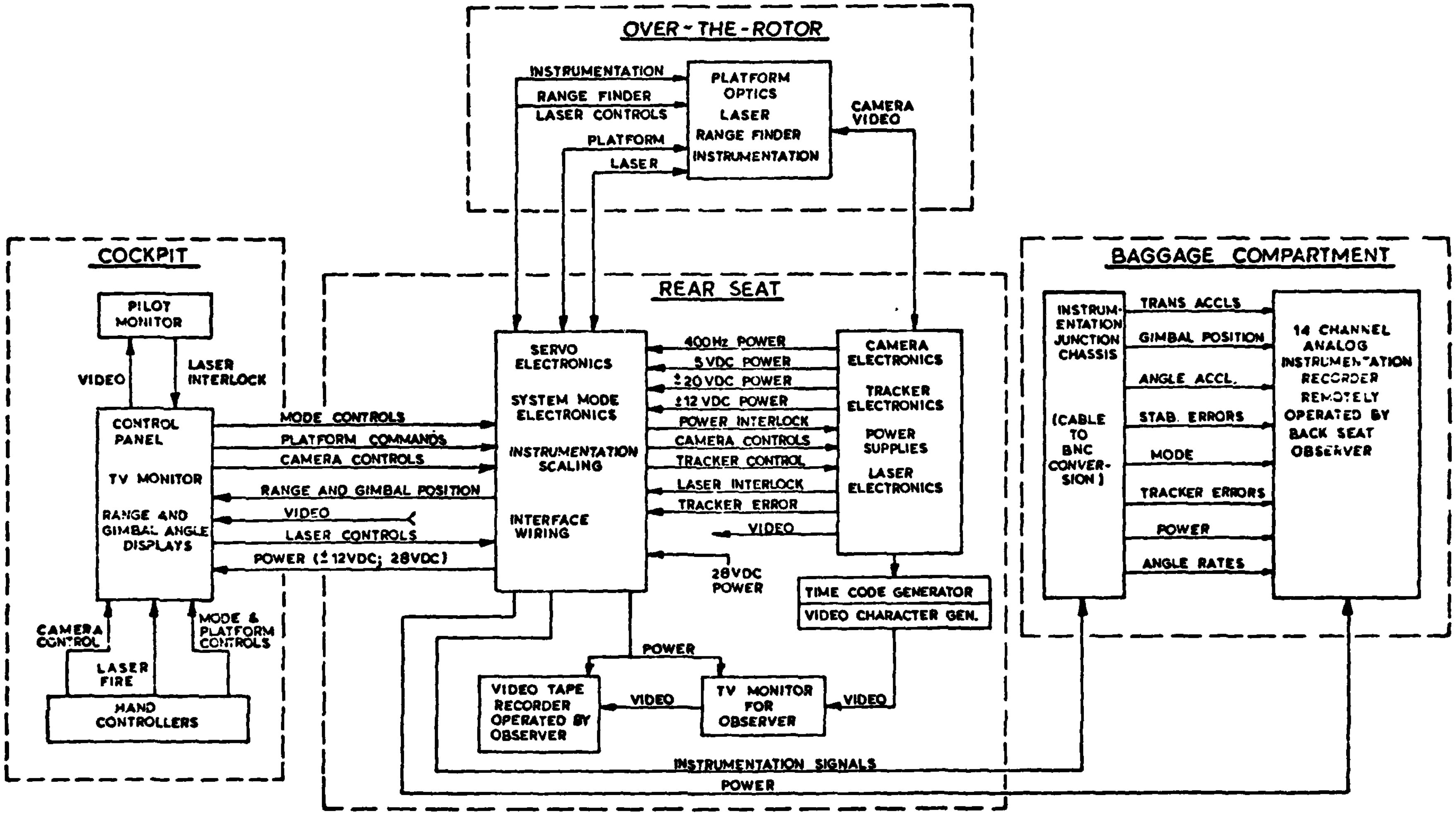

FIGURE 1. MMS SYSTEM BLOCK DIAGRAM

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TABLE 1. SYSTEM DESCRIPTION

Subsystem	Description
● TV System	
. Sensor	Silicon Vidicon with Spectral Response 0.71 to 0.95 μm
. Optics	
NFOV	2 Degree Diagonal, 3 Inch Diameter
WFOV	10 Degree Diagonal, 0.8 Inch Diameter
. Camera	4 X 3 Aspect Ratio, 525 TVL/RH Format
. Display	5.4 In. Diagonal, 600 TVL/RH Resolution
● Platform/Stabilization System	
. Configuration	Three Gimbal (Azimuth-Elevation-Azimuth) Assembly utilizing direct drive (brushless) torque motors and rate integrating gyros in 50 Hertz BW Servo Loops to stabilize the two (AZ-EL) Precision Gimbals
. *Gimbal Freedom*	
AZ	(Slew Mode $\pm$ 205° Elec Cage $\pm$ 170°)
EL	(Elec Cage & Slew Modes $\pm$ 22°)
● Tracker	Contrast Edge with Variable Aimpoint Offset
● Laser	FWL-103 modified to operate in 5 g's (At 11.8 Hertz) Translational Acceleration Environment
● Performance Goals	
. Stabilization	25 Microradians Each Axis
. System Resolution	50 Microradians in NFOV
. Recognition Range	3KM (Target Size 2.3M X 2.3M, 20% Contrast, 5KM Visibility)
. Precision Designation Range	3 KM (Target Size 2.3M X 2.3M, 28 MJ Output, 90% Energy on Target 90% Time)

TABLE 2. MODES OF OPERATION DESCRIPTION

Mode	Description	OIDC Controls
OFF	Prime power (28 VDC) is removed from electronics. Platform outer gimbal is mechanically caged.	System Power ON/OFF Switch
ACTIVATE	Prime power is applied to electronics and all electronics are activated. Outer Az gimbal remains mechanically caged and servo electrical cage loop is disabled for 25 seconds while gyros spin up. System automatically switches to ELEC CAGE mode after delay.	System Power ON/OFF Switch
ELEC CAGE and STAND-BY	Servo ELEC CAGE loops are closed and camera line-of-sight is maintained in the forward looking position, i.e., 0 degrees azimuth; 0 degrees elevation.	FORWARD CAGE Button - RH Grip
ELEC CAGE and STAND-BY	Servo ELEC CAGE loops are closed and camera line-of-sight is maintained at the selected position relative to the aircraft. Line-of-sight angular position is controllable by the GIMBAL POSITION potentiometers on the control panel.	GIMBAL POSITION CAGE Button - RH Grip
SLEW	Line-of-sight is inertially stabilized and accepts inertial rate commands from the thumb controllers for manual tracking or slewing to desired target for automatic tracking.	RH Grip Trigger 1ST DETENT
AUTO-TRACK	Line-of-sight is inertially stabilized and automatically maintained on a selected target by means of the servo track loop.	RH Grip Trigger 2ND DETENT
LASE	LASE is an auxiliary mode which can be commanded when the system is in the ELEC-CAGE, SLEW, AUTO-TRACK, AUTO-TRACK-AIMPOINT OFFSET or BORESIGHT modes. This is the laser firing mode.	LASER ARM Button-RH Grip; LH Trigger 1ST or 2ND DETENT; SAFE-ARM Switch (Located on PIDC)
BORESIGHT	BORESIGHT is an auxiliary mode which can be commanded when the system is in either the ELEC-CAGE or SLEW modes. This mode is used to align the video display cursors coincident with the laser beam position in the narrow field-of-view.	BORESIGHT RETRO Switch

TABLE 2. MODES OF OPERATION DESCRIPTION (continued)

Mode	Description	OIDC Controls
AIMPOINT OFFSET	AIMPOINT OFFSET is an auxiliary mode which can be commanded only when the system is in the AUTO-TRACK mode. This mode allows the operator to offset the tracking gate position with respect to the laser aimpoint (as defined by the video cursors) with inputs from the thumb controller. This mode is also known as Variable Aimpoint Offset.	OFFSET - LH Grip

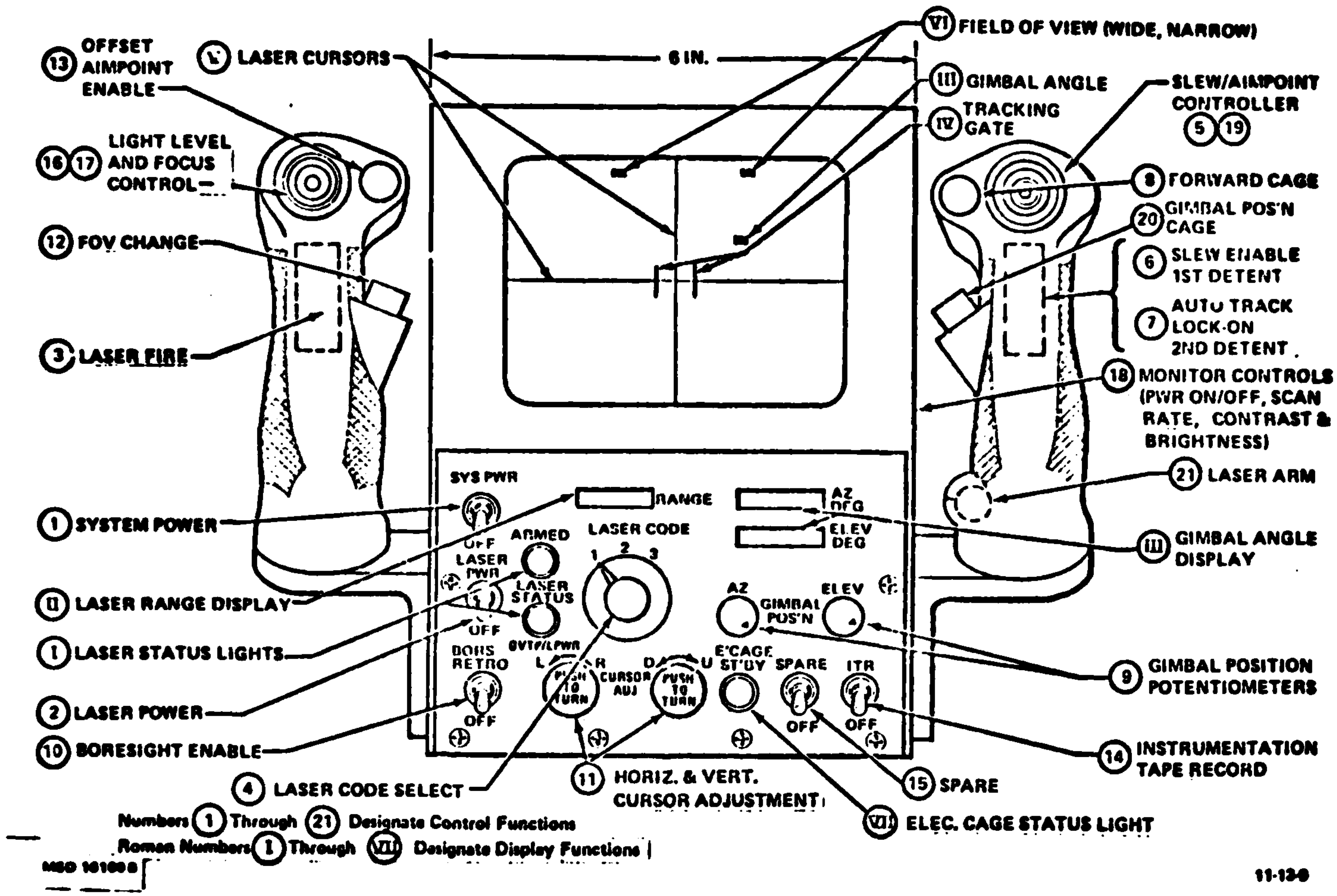

Figure 2. Operator's Imaging Display and Control

right hand grip trigger switch (6) to the first detent position. In this mode, the platform is inertially stabilized and accepts inertial rate commands from the right hand slew controller (5) or joystick as it is more commonly known. Releasing the trigger (6) or releasing and returning to the first detent does not change the mode of operation. Squeezing the trigger to the second detent position (7) switches the system to the TRACK mode in which the TV tracker locks on to the desired target. Releasing the trigger to the first detent or releasing it completely does not change the mode. Squeezing the trigger from the OFF (completely released) position to the first detent (6) when the system is in the TRACK mode returns the system to the SLEW mode. Depressing the OFFSET AIMPOINT ENABLE button (13) on left hand grip when the system is in the TRACK mode places the system in the VARIABLE AIMPOINT OFFSET mode in which the operator may command various offsets between the tracking gate (IV) and the laser's boresight indicated by the cursors (V). These offsets can be commanded from the right hand grip aimpoint controller or joystick (19) so long as the OFFSET ENABLE button is depressed. Releasing the OFFSET ENABLE button (13) stores the desired offset so long as the system remains in the TRACK mode. The offset (AIMPOINT) may be changed by depressing the AIMPOINT ENABLE (13) and selecting a new offset position via (19). The offsets are reset to zero whenever the system is commanded to either the SLEW or position modes. Either position mode (commonly called electrical cage) may be selected at any time by depressing either the FORWARD CAGE button (8) or the GIMBAL POSITION CAGE button (20). The system may be boresighted in either of the ELEC CAGE positions or SLEW mode. Boresighting the laser with the narrow field-of-view optics and camera/tracker may be performed by momentarily toggling the RETRO switch (10). This action causes a retro prism to drop into NFOV object space to reflect a small portion of the outgoing laser beam back into the system where the energy is imaged onto the silicon vidicon. The operator may then boresight the laser as viewed on his display by positioning the cursors via the CURSOR ADJ push-to-turn pots (11). Boresighting can normally be accomplished in less than 30 seconds at which time the retro prism automatically retracts, thereby removing the laser image from the display. Boresighting can be repeated if necessary. Verification of boresight accuracy can be accomplished by firing laser at "real world" target, observing the laser spot position with an IR camera or metascope and comparing that position with the laser position reference indicated by the cursors (V).

C. Cockpit Controls and Displays Definition

The following paragraphs present the requirements for the controls and displays necessary to operate the Mast Mounted Sight/Designator System when installed in the OH-58 helicopter. These requirements have been developed for the demonstration flight tests only.

1. Item Definition - The controls and displays shall provide the functional interface between the helicopter crew (pilot and operator) and the Mast Mounted Sight/Designator (MMS/D). They will enable the operator to detect, recognize, range, and laser designate targets while the pilot flies the helicopter behind masking media, out of sight from the target. Operation of the system's test instrumentation will be conducted by the back seat observer and is not covered in this document.

2. Major Components -

a. Operator's Imaging Display and Control (OIDC) - pronounced oi'dik. This unit is a pantograph-mounted television display including hand grips and switches similar to the Gunner's Imaging Display and Control (GIDC) developed for the HELLFIRE Cobra installation. The pantograph mount will allow the unit to be stowed on the floor of the helicopter between the feet of the operator and locked in place. The mount will also enable the television display to be moved by the operator for best viewing position during operation. The OIDC will be configured to withstand the flight loads in the operating conditions and the crash loads in the floor lock position. The observer flight controls (cyclic stick) shall be removed as required for installation of the OIDC during the flight test program.

b. Pilot's Imaging Display and Control (PIDC) - pronounced Pi'dik. This unit includes a television display and a key-operated laser arm switch mounted on the right side of the instrument panel in front of the pilot. This display presents the same video as that seen by the operator.

3. Control Requirements - All controls to operate the Mast Mounted Sight shall be incorporated into the OIDC except for the laser safety arm key switch located in the PIDC. The controls will be located on the two hand grips (right and left), the control panel (center), and TV monitor.

a. Operator Controls (See Figure 2)

(1) System Power - Provides ON/OFF control for power to activate the system electronics. It will be located on the control panel.

(2) Laser Power - Provides ON/OFF control for power to laser system. It will be located on the control panel.

(3) Laser Fire - A trigger type switch on left hand grip provides for control of laser firing by operator.

(4) Laser Code Select - Provides for selection of one of the three tri-service laser pulse codes stored in the laser encoder module. This three-position rotary switch is mounted on control panel.

(5) Slew Controller - Two-axis thumb-force controller mounted on right hand grip. This controller shall provide the inputs to activate the elevation and azimuth slew commands to the sight when operated in conjunction with the slew mode selected by the Slew Enable switch. See (6). A special thumb knob is provided for ease of 2-axis control. (The aimpoint function of this controller is covered in (19).)

(6) Slew Enable Mode Control - Provide signals that enable the slew controller to command the sight motion. It is a right hand grip trigger switch at first detent position.

(7) Automatic Track/Lock-on Mode Control - Provides signal that commands automatic tracker to initiate lock-on and automatic tracking of object within the tracking gate. This is the second detent in the trigger switch on the right hand grip.

(8) Forward Cage - Momentary thumb pushbutton on right hand grip commands line-of-sight to forward position, i.e., 0 degrees azimuth; 0 degrees elevation.

(9) Gimbal Position Adjust - Provides signals that will cause the azimuth and elevation gimbals to move to any position within their travel limits. Knob controls mounted on panel.

(10) Boresight Enable Mode Control - Provides signals that will allow the operator to boresight the laser cursors in the TV display with the laser. Momentary action of the BORESIGHT RETRO toggle switch on control panel activates this mode.

(11) Boresight Input Adjust - Provides signals to move the boresight cursors right or left and up or down. These adjustment controls will be mounted on the OIDC control panel and will consist of two push-to-turn pots to give independent cursor control.

(12) Field-of-View Size Control - A momentary push-button switch on the LH grip that commands the FOV to change each time the button is depressed. There are two fields-of-view (wide and narrow) and the prevailing FOV is identified by a visual cue (VI) on the TV monitor. The wide and narrow fields-of-view can be commanded at any time independent of other system modes. The cue in upper right quadrant denotes narrow field-of-view.

(13) Offset Aimpoint Enable - Offset aimpoint enable will provide signal to command the tracker gates to offset from the boresight of the laser. The signal will be generated with the thumb force controller. See (19). This action will only occur when the system is in the track mode. A momentary on push button switch will be provided on the LH grip.

(14) Instrumentation Tape Record - Provides ON/OFF power control for both the video and 14-channel data recording system by the operator. This switch also provides power control for the back seat monitor, the pilot's monitor and the time code/video character generators. Operation of the instrumentation is conducted by the back seat observer.

(15) SPARE Switch

(16) Camera Light Level Input Control - This control will provide a signal for the motor-driven neutral density filter on the TV camera to adjust for any variations in light level. It utilizes one axis of the two axes momentary 4-position ON/Center OFF toggle switch located on the left hand control grip. Downward thumb movement of the toggle switch reduces light level while movement upward increases it. A coolie-hat thumb knob is provided for ease of control. Light level and focus controls can be activated at any time independent of other system modes. (During the Engineering Development phase, the manual light level control will be automated thus relieving the operator from this additional task.)

(17) Camera Optical Focus Input Control - This control will provide the signal to energize the focus control on the camera optics. It utilizes the other axis of the switch described in (16) above. Thumb movement to the right causes the optics to focus closer to the helicopter while a movement to the left moves the focus further out. (During the Engineering Development phase, the manual focus control will be automated thus relieving the operator from this task.)

(18) Television Display Controls - The display will have separate controls to turn power on and to adjust contrast or brightness as required for image enhancement. They will be easily accessible from the right side of the monitor. A push button switch has also been provided for selection of scan rate which for this system is 525 lines per frame. Note that the display will not work if the 875 line scan rate is selected.

(19) Aimpoint Controller - Two-axis force-thumb controller mounted on right hand grip. This controller shall provide inputs to command an offset in the tracker gate position with respect to the laser aimpoint when operated in conjunction with the Offset Aimpoint Enable selected by pushbutton (13). (The slew function of this controller is covered in (5).)

(20) Gimbal Cage Mode Control - Provides signal that commands the gimbal system to align sight to the position set by Gimbal Position pots. Push button momentary action switch on right hand grip. Positioned for thumb operation.

(21) Laser Arm - Provides separate arm command to laser prior to firing. Located on back side of RH grip and operated with little finger.

4. Display Requirements - There will be two television displays, one for the observer and one for the operator. These displays will present the TV image from the Mast Mounted Sight/Designator vidicon camera along with other information. Several indicator lights are also required to display information to operator.

a. <u>Operator Television Display</u> - The requirements for the operator television display are presented in Specification VC476-5004 Rev. A dated 26 September 1977.

b. <u>Pilot Television Display</u> - This display is a commercially available 4-5 inch diagonal Sony TV monitor fitted with a glare (sun) shield.

c. <u>Operator Information Display</u> (See Figure 2) - The following items of information are required to be displayed to the operator during MMS operation:

(I) <u>Two Laser Status Lights</u> - The ARMED light will come on as a steady green light indicating that the laser is armed. This condition occurs after the laser arm button (21) has been depressed. The other light (below the ARMED light) is an amber light which flashes when the laser has either reached an overtemperature condition or its output power is below specification. See decal OVTP/LPWR.

(II) <u>Laser Range Indicator</u> - A digital display on panel provides direct readout of range in meters.

(III) <u>Gimbal Azimuth and Elevation Angle</u> - Digital display on panel provides direct readout of angles in degrees. The video marker or cue on the monitor displays the same information in a qualitative sense.

(IV) Tracking gate presented in video. Represented by area between the two short vertical bars. The two vertical bars will be flashing when the system is in the automatic track mode.

(V) Laser position boresight cursors presented in video. Center of laser located at intersection of horizontal and vertical cursors.

(VI) Field-of-view setting presented in video display. Wide FOV cue in upper left quadrant and Narrow FOV cue in upper right quadrant.

(VII) Electrical cage status light for standby mode.

d. <u>Pilot Information Display</u> - Same video presentation as the operator's.

II. GROUND TEST TURN-ON AND OPERATE PROCEDURE

This procedure is an outline of the steps required to operate the MMS/D System when installed on an OH-58C helicopter during ground test operations. Application of this procedure assumes that the operator is familiar with the nomenclature/location of MMS/D cockpit controls, displays and modes of operation.

Pre-MMS Turn-On Checklist:

(1) Before proceeding with functional checkout of the MMS/D, make certain that the various subsystem components, such as the servo box, TV monitor, camera/tracker chassis and the video tape recorder, have been properly installed in accordance with installation drawing requirements. See requirements defined by Figure 3. The instrumentation recorder (not shown in this figure) must also be properly installed in the rear electronics compartment.

(2) Before connecting the +28 VDC prime power input to the system from the helicopter, make certain that all cables and connectors have been installed in accordance with the requirements of Figure 4.

The following is a cable/connector check list:

✓	Cable *	Connectors
______	PCA-1	P24-J24
______	HCA-1	P77-J77, P50-J50, P51-J51, P57-J57
______	HCA-2	P54-J54, Two 25 Amp breakers
______	HCA-3	P66-J66, P61-J61 Coax
______	HCA-4	P55-J55, P63-J63
______	HCA-5	P59-J59, Coax to video character generator input
______	HCA-5A	Coax P73 to output of character generator
______	HCA-6	P60-J60, P62-J62 Coax
______	HCA-7	P58-J58 ITR Pwr. Box, P69-J69, P70-J70, P82-J82 static inverter, 400 Hz Pwr. Box to Video Character Generator
______	HCA-8	P71-J71, P72-J72

* PCA represents platform cable assembly and HCA designates helicopter cable assembly.

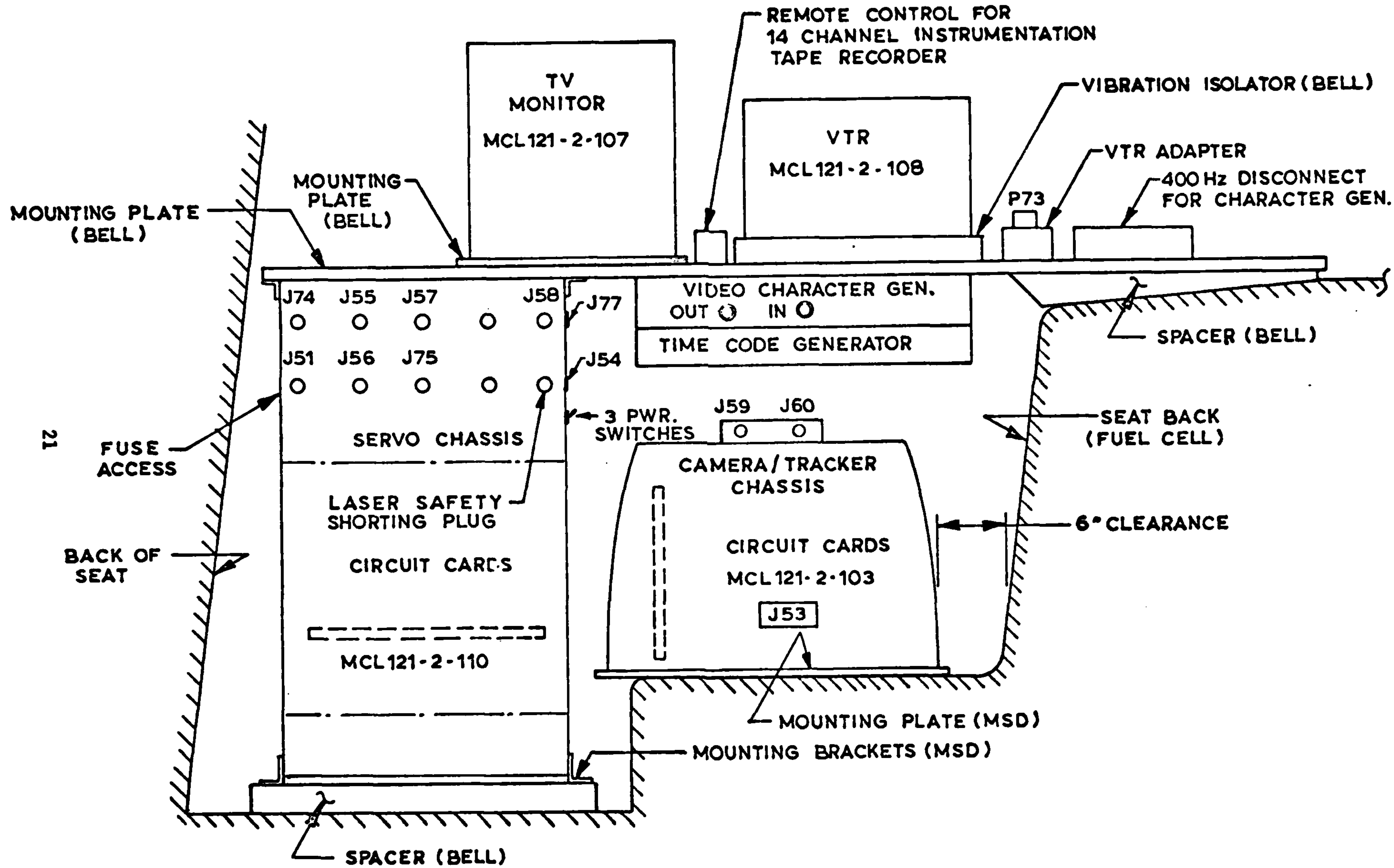

FIGURE 3. SKETCH - ELECTRONIC CHASSIS MOUNTING CONFIGURATION

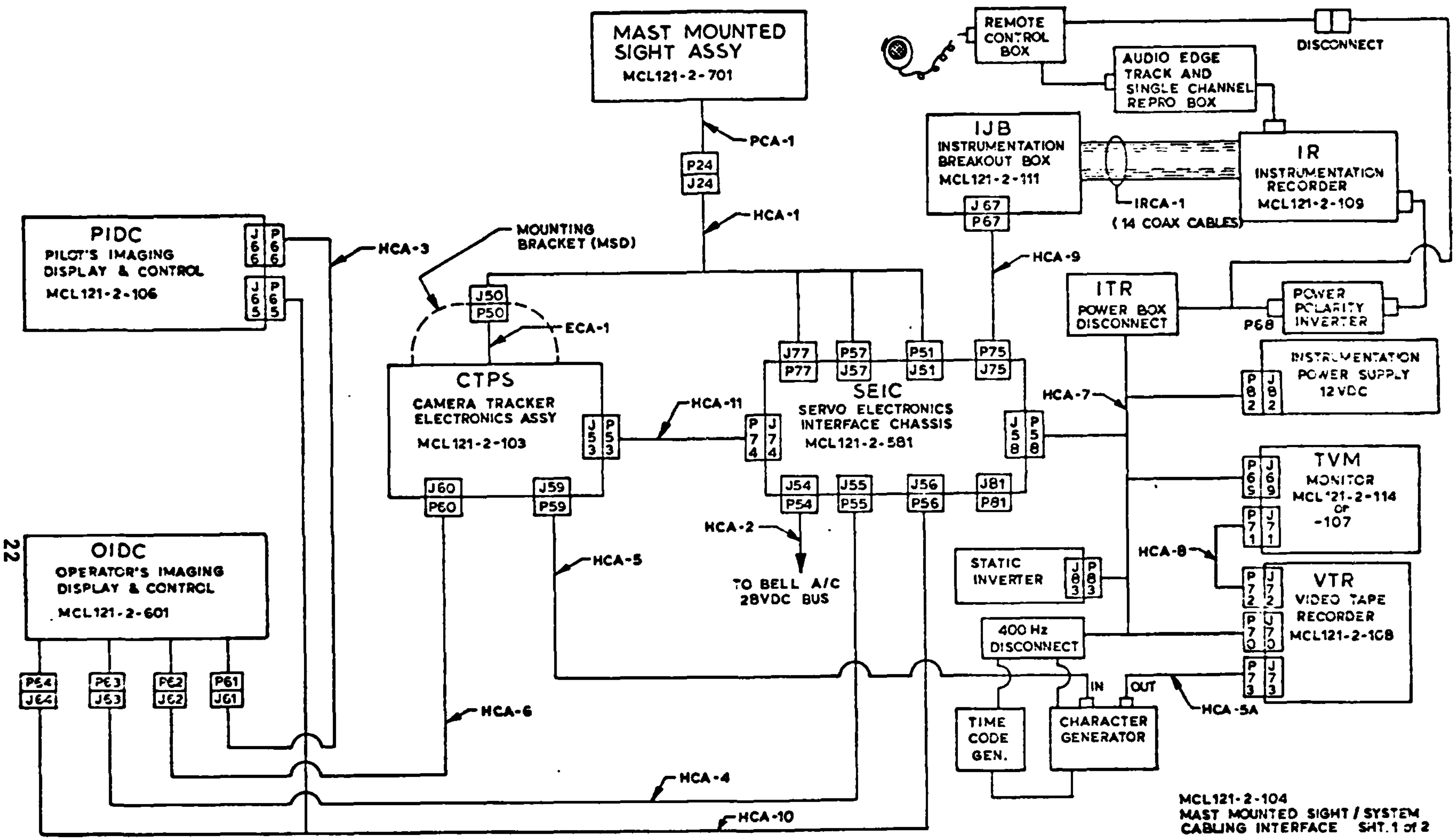

FIGURE 4. MAST MOUNTED SIGHT/SYSTEM CABLING INTERFACE

(2) (continued)

✓	Cable	Connectors
____	HCA-9	P67-J67, P75-J75
____	HCA-10	P56-J56, P64-J64, P65-J65
____	HCA-11	P53-J53, P74-J74

(3) Release OIDC* from stowed position before attempting any system operations. This may be accomplished by tilting the OIDC forward with the right hand while lifting up on the release lever with the left hand.

(4) Make certain that each switch on the OIDC panel is in its OFF position and that the Laser Safe Arm key switch on the PIDC* is in the SAFE position before proceeding. It is especially important for the system power and laser power switches to be OFF.

(5) Turn on MMS/D power switch located on cockpit panel (not to be confused with system power switch located on OIDC panel).

(6) Check for proper hookup and operation of external ground power cart to the helicopter. Turn on both helicopter 25 amp circuit breakers for MMS/D power.

MMS Turn-On and Checkout

(7) Turn on system power switch located on OIDC panel. Approximately 25 seconds after turn-on, the system will automatically switch to electrical cage mode or "standby" as indicated by the status light.

*OIDC - Operator's Imaging Display and Control
**PIDC - Pilot's Imaging Display and Control

By this time the operator should be able to view a scene on the monitor dependent upon where the MMS/D is pointed. It may be necessary at this point to adjust the manual light level control for the "best" TV display. This also holds true for the manual focus control as required. Exercising the light level and focus controls may be required from time to time during the ground and flight tests due to a number of parameter variations such as range, light level, scene content and temperature. Operator response and preference are also factors which enter into the adjustment of light level and focus. (Note: For the operational scenario, the light level control and the focus control will be automated.) All of the monitor display symbols should be clearly visible including the laser cursors, tracking gate, gimbal angle and one field-of-view (either wide or narrow). The monitor should present a clear, stable image to the operator. Operator and pilot should make preliminary adjustments to their respective monitors at this time. Information content in both monitors should be the same. Operator should note that the gimbal angle cue is in a fixed position and that the digital gimbal angle readouts correspond in sign and magnitude with the video cue.

(8) Turn on instrumentation tape recorder (ITR) power switch. Back seat observer will operate all instrumentation controls and verify that they are functioning.

(9) Observer will turn on the video tape recorder (VTR) and verify that it is recording properly. He will also set up the time code/video character generator for the specified mission and record this information on both the video tape recorder and the instrumentation tape recorder.

(10) Exercise the field-of-view changer on the LH grip and observe that the appropriate cues switch back and forth between the upper two quadrants of the TV monitor in accordance with the pushbutton commands.

(11) Place the sytem in slew mode with the RH trigger switch (1st detent) and slew the system to desired targets within the system gimbal limits using the RH thumb-force controller. Observe that the gimbal angle cue moves in accordance with these commands. As the sight slews left, so should the gimbal angle cue on the monitor. When the sight reaches the prescribed limit of -205 degrees the cue on the monitor should just touch the left edge of the raster. It is undesirable to slew the system into its mechanical limit of 210 degrees; thus the system automatically precludes such an occurrence by electrically limiting the freedom to 205 degrees. The same action may be observed when slewing the system to the right.

For elevation slew, the gimbal freedom is electrically limited at -22° down (bottom of the raster) and $+22^{\circ}$ up (top of the raster).

(12) After slewing system to desired edge of target within the tracking gate, place the system in auto track mode by squeezing the RH trigger switch to the 2nd detent. Observe that system tracks desired edge of target with no further control commands. Also, observe that the tracking gate cue flashes in the track mode.

> <u>WARNING</u>:
>
> BEFORE UNDERTAKING THE NEXT STEP, MAKE CERTAIN THAT ALL LASER SAFETY PRECAUTIONS HAVE BEEN TAKEN AND THAT A CLEARANCE HAS BEEN ISSUED BY THE LASER OR RANGE SAFETY OFFICE. (SEE SECTION ON LASER SAFETY PROCEDURE) IF CLEARANCE HAS NOT BEEN GRANTED, PROCEED TO STEP 25.

<u>Laser Operation</u>:

(13) Turn key operated Laser Arm Switch located on PIDC from SAFE to ARM position.

(14) Turn Laser Power Switch to ON and observe that the ARMED laser status green light illuminates.

(15) Place the Laser Code Select switch to #2 position for ranging at 10 pps.

(16) To boresight the laser with the laser cursors, switch the system to GIMBAL POSITION CAGE.

(17) Toggle the BORS/RETRO switch momentarily and pull the LH trigger switch to the 1st detent position to fire the laser. Observe a small portion of the outgoing laser energy as reflected back to the vidicon via the retro-reflector and displayed as a small spot on the monitor.

(18) Position the sight via the gimbal null position pots so that the laser spot designates the desired target or target area.

(19) Verify that the laser range readout corresponds to the <u>known</u> range of the designated target within ±10 meters.

(20) Push D↔U PUSH-TO-TURN knob and rotate for up and down adjustment of horizontal cursor position. Position the cursor accurately so that it passes through the laser spot horizontally. Repeat this procedure for the vertical cursor adjustment using the L↔R PUSH-TO-TURN pot.

The purpose of the push-to-turn type pot is to provide mechanical memory of the boresighted position so that if power is removed from the system and later restored, it will not be necessary to

(20) (continued)

re-boresight. The push-to-turn feature precludes accidental changes to the boresight position during operational use of other OIDC functions.

This essentially completes the boresight operation. Normally, this can be completed in less than 30 seconds at which time the retro automatically retracts. If more time is required, the retro switch can be reactivated.

(21) Boresighting can also be accomplished in the slew mode by slewing the sight so that the laser spot remains fixed on the target while simultaneously adjusting the cursors to pass through the laser spot.

(22) Observe that under normal conditions, the OVTP/LPWR (over temperature/low power) laser status light will be out. It will, however, illuminate as a steady amber light if the laser overheats. Should this occur, the laser will sense this condition and automatically disarm itself and the ARMED light will go out. The operator will not be able to re-ARM the laser until it has sufficiently cooled down.

Steps (16) thru (21) describe an autonomous boresight method which the operator can employ at any time throughout the mission to assure himself that the laser points where the cursors indicate.

(23) A non-autonomous boresight technique will also be employed during early stages of evaluation to determine the validity of the above retro reflector boresight system. It is more commonly known as "real world target boresighting". With this approach, the boresight retro switch need not be used. Either the electrical cage or slew mode is selected. With an external IR camera or metascope operated by a remote observer to observe the laser spot on the desired target directly, the MMS operator can be directed to positionthe cursors so that they pass through the designated target. When this is accomplished, he may then switch to BORS/RETRO to validate the retro lens design approach.

(24) Slew the system to a desired target and lock-on.

(25) To offset the tracker gate with respect to the laser aimpoint as defined by the boresighted laser cursors, depress the offset aimpoint enable button on the LH grip and with the 2-axis aimpoint controller on the RH grip, introduce the desired offset. Release the aimpoint enable button and observe that the system will maintain this new offset position between the laser and the tracking gate; i.e., the laser will continue to designate one spot while the system tracks another. To change the prevailing offset, simply repeat the above process. As soon as the system is commanded out of track to another mode such as slew or cage, the offset will automatically be re-set to zero in preparation for the next track mode exercise.

(26) Switch to slew mode and then back to track mode and observe that the previously introduced variable aimpoint offset has been reset to zero.

(27) Return system to Stand-By mode or electrical cage.

(28) At this point, all system functions have been adequately exercised for ground checkout.

MMS/D SHUT-DOWN PROCEDURE

Before bringing helicopter rotor blade up to speed and commanding power change over to the rotor generator, turn off the MMS/D in the following right-to-left sequence:

a) PIDC key operated safe arm switch from ARM to SAFE

b) Laser power switch to OFF

c) ITR to OFF

d) Command forward cage

e) System power switch to OFF

III. FLIGHT TEST, TURN-ON AND OPERATE PROCEDURE

This procedure is an outline of the steps required to operate the MMS/D as installed on an OH-58C helicopter during flight test operation. Application of this procedure assumes that the operator is familiar with the nomenclature/location of MMS/D cockpit controls, displays and modes of operation. It is also assumed that the Ground Test Turn-On and Operate Procedure was successfully applied prior to application of this procedure. Many of the steps from the ground test checkout have been repeated here in order to make this a self-contained set of instructions without the need to refer back to prior operating instructions.

Engine Start-up:

(1) Wait for a minimum of 1 minute after completing the MMS/D shut-down procedure before starting the helicopter engine.

(2) Allow helicopter blade speed to stabilize above 90% of N_2 (Power Turbine RPM) before turning on system power.

MMS/D System Checkout and Helicopter Take-off:

(3) Before take-off, turn on system power switch located on OIDC panel. Approximately 25 seconds after turn-on, the system will automatically switch to electrical cage mode or "standby" as indicated by the status light. Helicopter take-off may occur at any time after reaching standby mode.

By this time the operator should be able to view a scene on the monitor dependent upon where the MMS/D is pointed. It may be necessary at this point to adjust the manual light level control for the "best" TV display. This also holds true for the manual focus control as required. Exercising the light level and focus controls may be required from time to time during the ground and flight tests due to a number of parameter variations such as range, light level, scene content and temperature. Operator response and preference are also factors which enter into the adjustment of light level and focus. (Note: For the operational scenario, the light level control and the focus control will be automated.) All of the monitor display symbols should be clearly visible including the laser cursors, tracking gate, gimbal angle and one field-of-view (either wide or narrow). The monitor should present a clear, stable image to the operator. Operator and pilot should make preliminary adjustments to their respective monitors at this time. Information content in both monitors should be the same. Operator should note that the gimbal angle cue is in a fixed position and that the digital gimbal angle readouts correspond in sign and magnitude with the video cue.

(4) Turn on instrumentation tape recorder (ITR) power switch. Back seat observer will operate all instrumentation controls and verify that they are functioning.

(5) Observer will turn on the video tape recorder (VTR) and verify that it is recording properly. He will also set up the time code/video character generator for the specified mission and record this information on both the video tape recorder and the instrumentation tape recorder.

(6) Exercise the field-of-view changer on the LH grip and observe that the appropriate cues switch back and forth between the upper two quadrants of the TV monitor in accordance with the pushbutton commands.

(7) Place the system in slew mode with the RH trigger switch (1st detent) and slew the system to desired targets within the system gimbal limits using the RH thumb-force controller. Observe that the gimbal angle cue moves in accordance with these commands. As the sight slews left, so should the gimbal angle cue on the monitor. When the sight reaches the prescribed limit of -205 degrees the cue on the monitor should just touch the left edge of the raster. It is undesirable to slew the system into its mechanical limit of 210 degrees; thus the system automatically precludes such an occurrence by electrically limiting the freedom to 205 degrees. The same action may be observed when slewing the system to the right.

For elevation slew, the gimbal freedom is electrically limited at -22° down (bottom of the raster) and $+22^{\circ}$ up (top of the raster).

(8) After slewing system to desired edge of target within the tracking gate, place the system in auto track mode by squeezing the RH trigger switch to the 2nd detent. Observe that system tracks desired edge of target with no further control commands. Also, observe that the tracking gate cue flashes in the track mode.

> <u>WARNING</u>:
>
> BEFORE UNDERTAKING THE NEXT STEP, MAKE CERTAIN THAT ALL LASER SAFETY PRECAUTIONS HAVE BEEN TAKEN AND THAT A CLEARANCE HAS BEEN ISSUED BY THE LASER OR RANGE SAFETY OFFICE. (SEE SECTION ON LASER SAFETY PROCEDURE) IF CLEARANCE HAS NOT BEEN GRANTED, PROCEED TO STEP 25.

<u>Laser Operation</u>:

(9) Turn key operated Laser Arm Switch located on PIDC from SAFE to ARM position.

(10) Turn Laser Power Switch to ON and observe that the ARMED laser status green light illuminates.

(11) Place the Laser Code Select switch to #2 position for ranging at 10 pps.

(12) To boresight the laser with the laser cursors, switch the system to GIMBAL POSITION CAGE.

(13) Toggle the BORS/RETRO switch momentarily and pull the LH trigger switch to the 1st detent position to fire the laser. Observe a small portion of the outgoing laser energy as reflected back to the vidicon via the retro-reflector and displayed as a small spot on the monitor.

(14) Position the sight via the gimbal null position pots so that the laser spot designates the desired target or target area.

(15) Verify that the laser range readout corresponds to the <u>known</u> range of the designated target within $\pm$10 meters.

(16) Push D↔U PUSH-TO-TURN knob and rotate for up and down adjustment of horizontal cursor position. Position the cursor accurately so that it passes through the laser spot horizontally. Repeat this procedure for the vertical cursor adjustment using the L↔R PUSH-TO-TURN pot.

The purpose of the push-to-turn type pot is to provide mechanical memory of the boresighted positions so that if power is removed from the system and later restored, it will not be necessary to

(continued)

re-boresight. The push-to-turn feature precludes accidental changes to the boresight position during operational use of other OIDC functions.

This essentially completes the boresight operation. Normally, this can be completed in less than 30 seconds at which time the retro automatically retracts. If more time is required, the retro switch can be reactivated.

(17) Boresighting can also be accomplished in the slew mode by slewing the sight so that the laser spot remains fixed on the target while simultaneously adjusting the cursors to pass through the laser spot.

(18) Observe that under normal conditions, the OVTP/LPWR (over temperature/low power) laser status light will be out. It will, however, illuminate as a steady amber light if the laser overheats. Should this occur, the laser will sense this condition and automatically disarm itself and the ARMED light will go out. The operator will not be able to re-ARM the laser until it has sufficiently cooled down.

Steps (12) thru (17) describe an autonomous boresight method which the operator can employ at any time throughout the mission to assure himself that the laser points where the cursors indicate.

(19) A non-autonomous boresight technique will also be employed during early stages of evaluation to determine the validity of the above retro reflector boresight system. It is more commonly known as "real world target boresighting". With this approach, the boresight retro switch need not be used. Either the electrical cage or slew mode is selected. With an external IR camera or metascope operated by a remote observer to observe the laser spot on the desired target directly, the MMS operator can be directed to positionthe cursors so that they pass through the designated target. When this is accomplished, he may then switch to BORS/RETRO to validate the retro lens design approach.

(20) Slew the system to a desired target and lock-on.

(21) To offset the tracker gate with respect to the laser aimpoint as defined by the boresighted laser cursors, depress the offset aimpoint enable button on the LH grip and with the 2-axis aimpoint controller on the RH grip, introduce the desired offset. Release the aimpoint enable button and observe that the system will maintain this new offset position between the laser and the tracking gate; i.e., the laser will continue to designate one spot while the system tracks another. To change the prevailing offset, simply repeat the above process. As soon as the system is commanded out of track to another mode such as slew or cage, the offset will automatically be re-set to zero in preparation for the next track mode exercise.

(22) Switch to slew mode and then back to track mode and observe that the previously introduced variable aimpoint offset has been reset to zero.

(23) Return system to Stand-By mode or electrical cage.

(24) At this point, all system functions have been adequately exercised for ground checkout.

Mission Flight Test:

(25) Conduct flight test in accordance with the mission plan as briefed. Make certain that the VTR and ITR are turned on so that all data can be recovered and reviewed during post-flight de-brief and data reduction.

The pilot and observer's comments and observations during the mission should also be preserved as a matter of record. They will be extremely valuable during post-flight data reduction and evaluation, particularly in regard to flight conditions at the time of target detection, recognition, acquisition, designation, ranging, breaklock, slew, boresight, etc. This will be accomplished by tying the helicopter's intercom to the audio input channel of the VTR.

(26) Note that the MMS system can be cycled off and on at will throughout the flight provided that the turn-off and turn-on procedures are followed:

MMS Shut-Down Procedure:

(27) Before landing the helicopter, turn off the MMS/D in the following right-to-left sequence:

a) PIDC key operated safe arm switch from ARM to SAFE

b) Laser power switch to OFF

c) ITR to OFF

d) Command Forward Cage

e) System power switch to OFF

(28) Stow the OIDC in the locked-down position in preparation for landing. Allow a minimum of 1 minute between MMS power shut-down and helicopter landing.

IV. INSTRUMENTATION EQUIPMENT DESCRIPTION AND OPERATION

A. Equipment Description

The instrumentation equipment to be installed on the OH-58C helicopter for the initial flight tests of the MMS system consists of (1) angular and translational motion transducers, (2) a 14-channel analog recorder, (3) a video tape recorder, and (4) a TV monitor. The specific components incorporated in the instrumentation system and the performance characteristics of each component are presented in Table 3. The specific signals to be recorded are presented in Table 4.

B. Recording Procedure

The operational procedures for the Sony TV monitor, the Sony video tape recorder, and the Pemtek analog recorder are described in the commercial manuals for these units. The TV monitor, VTR, and ITR will be manually operated by the back seat observer.

V. LASER SAFETY PROCEDURES

The laser subsystem is a modified International Laser Systems, Inc. Model FWL-103 laser. The output characteristics of the laser are listed in Table 5.

1.1 *Safe/Arm Conditions*

The laser subsystem and operating controls incorporate a set of interlocks to ensure that an output laser pulse will not be inadvertently generated.

1.1 Laser Safe Condition

A laser SAFE condition is obtained when either or both the Pilot's Laser Safe/Arm Switch and Operator's Laser Power Switch are in the SAFE and/or OFF positions respectively. These switches are in series with the laser power supply interlock circuit.

1.2 Laser Arm and Fire Conditions

A laser Arm condition is obtained when all of the following conditions have been established:

(a) MMS/D System Power Switch is ON

(b) Pilot's Laser Safe/Arm Switch is in the ARM position

(c) The Operator's Laser Power Switch is in the ON position

(d) A/C prime power is applied to the system

TABLE 3. INSTRUMENTATION EQUIPMENT

ITEM	DESCRIPTION	PERFORMANCE	LOCATION
1. Translational Accelerometers	Schaevitz Model LSMP-20	Range + 20 g's BW = DC to 150 Hz Accuracy $\approx 1\%$	3 units at MMS CG Orthogonal IA's
2. Angular Accelerometer	Schaevitz Model ASMP-500	Range $\pm$ 500 Rad/Sec^2 BW = DC to 100 Hz Accuracy $\approx 5\%$	1 Unit on inner gimbal IA $\parallel$ LOS
3. Rate Gyro	Hamilton Standard Model Supergyro	Range $\pm$ 100 Deg/Sec BW = DC to 50 Hz Accuracy $\approx 2\%$	2 Units on MMS/D lower frame. IA's normal to LOS
4. Stabilization Gyros	Northrup Model GI-G6 (Demodulated Pickoff)	Range $\pm$ 1.6 milliradians BW = DC to 100 Hz Accuracy $\approx 1\%$ Resolution $\approx$5 microradians	2 Units on inner gimbal normal to LOS
5. Tracker	Condor Edge Tracker	Range $\pm$ 1/2 raster BW = DC to 5 Hz Accuracy $\approx 5\%$	Rear Seat
6. Position Pickoffs	Resolvers Eℓ Vernitron type VSP34 Az Weston Custom Resolver to DC Converters	Range $\pm$ 20 degrees Range $\pm$ 180 degrees BW = DC to 20 Hz Accuracy $\approx 5\%$	MMS/D Eℓ gimbal MMS/D Outer Az gimbal
7. TV Monitor	Sony CVM-115	See Manual	Rear Seat
8. Video Tape Recorder	Sony AV 3400	See Manual	Rear Seat
9. Anglog Recorder	Pemtek 110-A	See Manual	Baggage Compartment
10. Video Character/Time Code Generators	Chronolog	See Manual	Rear Seat

TABLE 4. INSTRUMENTATION SIGNALS

MAST MOUNTED SYSTEM PARAMETERS

ROCKWELL INSTR. BREAKOUT BOX CONNECTOR	PARAMETER DESCRIPTION	PARAMETER SENSITIVITY	BAND EDGE
A	Azimuth Stabilization	140 μrdn/v	1 volt P-P
B	Elevation Stabilization	100 μrdn/v	1 V P-P
H	$\ddot{\phi}$ Angular Acceleration About LOS	30 rdn/sec^2/v	2 V P-P
J	Lateral Acceleration	1.04 G(peak)/v	2 V P-P
K	Longitudinal Acceleration	1.70 G(peak/v	2 V P-P
L	Vertical Acceleration	1.04 G (peak)/V	2 V P-P
R	Horizontal Tracker	$\simeq$10 V/Raster	.2 V P-P
S	Vertical Tracker	$\simeq$10 V/Raster	.2 V P-P
U	Lower Frame Yaw Rate	17°/sec/V	2 V P-P
V	Lower Frame Pitch Rate	17°/sec/V	2 V P-P
E	AZ Position	100°/V	3.6 V P-P
F	EL Position	10°/V	3.6 V P-P
<u>P</u>	Aircraft Primary DC Pwr (24-30V)	.036 V/V	1.2 V Peak
Z	AZ LOS Rate (Gyro Torquer Current)	9.09°/sec/V	1 V P-P
<u>A</u>	EL LOS Rate (Gyro Torquer Current)	9.09°/sec/V	1 V P-P
<u>C</u>	Range	TBD	TBD
<u>E</u>	AZ Pwr. Ampl. Cmd.	-	-
<u>F</u>	EL Pwr. Ampl. Cmd.	-	-
<u>H</u>	+15 VDC	-	-
<u>I</u>	-15 VDC	-	-
<u>J</u>	±15 V Rtn	-	-
<u>K</u>	AZ Slew Cont. (Joystick)	TBD	TBD
<u>M</u>	EL Slew Cont. (Joystick)	TBD	TBD
BHT Instr. Breakout Box Connector			
P.V.	Pilot Seat Vertical Accl.	1.316G (peak)	
P.L.	Pilot Seat Lateral Accl.	0.982 G/V	
P.F.A.	Pilot Seat Fore & Aft	0.864 G/V	
C.V.	Co-Pilot Seat Vertical	1.365 G/V	
C.L.	Co-Pilot Seat Lateral	0.997 G/V	
C.F.A.	Co-Pilot Seat Fore & Aft	0.741 G/V	
MMS F/A	MMS Fore & Aft Posn. Pot.	0.474 Inches/V	
MMS Lat.	MMS Lateral Posn. Pot.	0.474 Inches/V	

TABLE 5

LASER OUTPUT DATA

WAVE LENGTH	1.06μ
OUTPUT POWER (System)	≈ 35 mj
PULSE RATE	10-20 pps PRF CODEABLE AND SINGLE SHOT
PULSE WIDTH	20 nanosec.
OUTPUT BEAM DIVERGENCE (System)	$\leq 200\ \mu r$

(e) Laser safety shorting plug has been installed on servo box

(f) Laser Power Switch has been turned ON at servo box

(g) ARM button has been depressed on the RH grip by operator

To fire the laser, the operator depresses the Laser Fire Switch on the left hand grip at the index finger position. The laser will then emit energy pulses at the pulse rate selected by the position of the Code Select Switch. The laser will instantly stop firing whenever the operator releases the LH grip trigger switch.

2. <u>Laser Safety Procedure</u>

The following safety procedures must be considered.

A. The key for the Pilot's Laser Safe/Arm Switch should be controlled in the same manner as the A/C ignition key or door key.

B. All air crew members must wear laser protective visors or goggles when the Pilot's Laser Safe/Arm Switch is in the ARM position. This applies to crew members of other aircraft participating in the test program.

C. Test and evaluation areas must be approved for laser operation. All personnel in the test area must wear laser goggles or be in a protective enclosure; i.e., no windows or solid window covers in place (curtains are not adequate protection) during laser operation.

D. A Laser or Range Safety Officer shall be appointed and shall have the final authority on all laser operation. He shall also investigate all eye injury reports.

E. All personnel engaged in the operation, test or evaluation of the MMS/D should have an eye examination, including a retinal photograph, prior to active participation in the program.

F. Laser maintenance and repair shall be performed in an area approved for laser operation by the laser safety officer. Maintenance shall be performed by authorized personnel only.

G. A protective cover shall be installed over the at all times the system is not in operation.

APPENDIX B

MAST MOUNTED SIGHT/DESIGNATOR

LASER SAFETY OPERATING PROCEDURE

MAST MOUNTED SIGHT/DESIGNATOR

LASER SAFETY OPERATING PROCEDURE

1.0 PURPOSE

This procedure describes the safety procedures to be following while operating, aligning, testing or repairing the Mast Mounted Sight/Designator (MMS/D) or its laser subsystem at Rockwell International.

2.0 APPLICABLE DOCUMENTS

A. Rockwell Safety Procedure J-05 Lasers - Potential Hazards and Controls
B. TN 765-7-78 Mast Mounted Sight/Designator Operating Procedure
C. American National Standard ANS1Z-136.1 for Safe Use of Lasers

3.0 PROJECT LASER SAFETY OFFICER

C. I. Goodrich has been appointed MMS/D Laser Safety Officer. He will be responsible for training technicians in the safe operation of the MMS/D system and coordinating project safety problems and requirements.

4.0 POTENTIAL HAZARDS

The MMS/D sight unit contains a neodymium laser subsystem whose raw beam output is routed across the gimbals to an 11-power telescope in the payload assembly. The telescope expands the beam and improves its collimation while projecting it out of the sight unit. The characteristics of the raw beam are listed in Table 1.

TABLE 6. LASER BEAM OUTPUT CHARACTERISTICS

<u>Laser Subsystem</u>

Raw Beam Characteristics:

Output Power	75 to 80 x 10^{-3} J
Output Beam Dia.	0.22 inch Max
Output Divergence	1.5 x 10^{-3} rad. Max
Output Pulse Width	20 x 10^{-9} sec. typical
Output PRF	Codeable 10 to 20 pps and 1 pps

<u>Mast Mounted Sight/Designator System</u>

Output Beam Characteristics:

Power	Nominal 35 x 10^{-3} J
Diameter	2.8 inches Max
Beam Divergence	0.2 x 10^{-3} rad. Max
Pulse Width	20 x 10^{-9} sec.
PRF	Codeable 10 to 20 pps and 1 pps

The MMS/D and laser subsystems are Class IV laser systems as determined using the ANSIZ136.1 criteria. Laser systems in this class have the potential to cause eye and skin damage. In addition, the laser subsystem contains high voltage which is potentially hazardous when the protective housing is removed.

5.0 LABORATORY OPERATION

5.1 System Operation

5.1.1 The MMS/D system shall be turned on and operated in accordance with the operating procedures of TN 765-7-78. The laser shall be fired only by authorized personnel in approved laboratory facilities.

5.1.2 All alignment and testing of laser subsystem on the MMS/D platform shall be performed with platform servo drives disabled and the gimbal system mechanically caged except when otherwise specifically required by a test procedure.

5.1.3 Absorbing material shall be used to terminate the laser beam and limit the length of the optical path. The length of the laser path shall be limited to the shortest distance required to perform the required tests and folding the test path shall be avoided wherever possible.

5.1.4 The laser power jumper connector shall be removed and replaced with a connector tieing into the laboratory door interlock system. Both of these connectors shall be removed from the system electronics except when laser operation is required.

5.1.5 When the environmental cover is removed from the system, the open laser path throughout the gimbals shall be covered to prevent foreign objects intruding into the laser path (e.g., system wiring).

5.1.6 When the sight environmental cover is removed, the laser path shall be blocked at the top of the trunnion using the stop provided, except when the laser is to be fired.

5.1.7 The range receiver shall be disabled when operating the laser in the laboratory.

5.2 Laser Subsystems Operation

5.2.1 The laser subsystem shall be operated and opened only by authorized personnel in accordance with International Laser System (ILS) procedure.

5.2.2 The laser subsystem input power shall be tied into the laboratory door interlock system. The input power connector shall be removed from the laser except when the system is to be operated.

5.2.3 Absorbing material shall be used to terminate and limit the length of the laser path. The length of the laser path shall be limited to minimum distance required to perform the required tests and folding the path shall be avoided wherever possible.

5.2.4 The beam output aperture shall be blocked except when the laser subsystem is to be operated.

6.0 PERSONNEL PRECAUTIONS

6.1 The personnel assigned to operate, align, maintain, test, and inspect the MMS/D systems shall have a current certification from Department 073 Technical Training in the safe use of laser and safety procedure J-05. Only those certified personnel instructed in the operation of the MMS/D system shall be authorized to fire the laser. The project laser safety officer shall instruct assigned personnel in the operation of the MMS/D system and laser subsystem.

6.2 All personnel assigned to operate, align, maintain, test and inspect the MMS/D system shall adhere to the following safety precautions when working around the system:

a. Personnel should never look into the windows or lenses of the MMS/D system or at specular reflections of the beam.

b. The MMS/D system or laser subsystem shall never be aimed by eye by looking along the beam axis. Alignment shall be performed by tracking the burn spot made by the laser beam on suitable material. Tape, paper, or Poloroid film may be used for tracking the beam.

c. All personnel who could be exposed to the laser output of the MMS/D shall wear laser safety goggles during system laser operation. The goggles hsall have minimum optical densities of ≥ 6 at 1.064 μm and 0.6328 μm. Laser safety goggles shall be obtained from the Industrial Hygiene and Safety Department (D/038).

d. The person (s) operating the MMS/D system laser shall warn all personnel to put on their goggles and shall perform a count down prior to firing the laser. The lead operator shall be responsible for insuring that the laser jumper connector has been removed and the system tied into the laboratory door interlock system and that the door interlock system is operating.

e. The lead operator shall be responsible for insuring that the system is not left unattended while energized. He shall also insure that the laser jumper connector and the key to the power switch are removed from the system and properly stored when shutting down the MMS/D system.

f. Jewelry, watches, rings, etc. shall not be worn when working in and around the laser beam. The laser beam shall be terminated by non-reflective fire resistant material.

7.0 FACILITIES

7.1 The laboratory in which the MMS/D system will be operated, aligned, maintained, tested and inspected shall conform to the requirements outlined in safety procedure J-05, except that the walls shall be painted flat white and polished, specular and glass surfaces shall be made diffuse before painting. (It should be noted that when a laser beam impinges on a painted surface, a portion of the paint is blown away and the polished surface becomes exposed.) Emergency exit doors must be interlocked to the laser so that the system is shut down when the door is opened.

8.0 MEDICAL SURVEILLANCE

All personnel shall have current eye examination in accordance with J-05 and shall report suspected laser related injuries to the Medical Department and the Project Laser Safety Officer.

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